Computed tomography-based acute stroke lesion timing and patient stratification

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Minnerup and co-workers proposed a computed tomography (CT) –based procedure to determine age of acute/hyperacute stroke to aid patient stratification for reperfusion therapy [1]. The CT procedure converts Hounsfield Units (HU) determined in the stroke lesion into net water uptake due to ischaemia. There are issues in the paper that deserve attention. First, Minnerup et al [1] determined an average increase of brain water by 4.8% in ischaemic core within 4.5 hours (mean time 2.1 hours), rising to 11.5% at 4.5 hours. This value is very high in the light of directly measured water uptake at 4 hours in a primate (1.6 - 2.4% [2]), feline (1.2% [3]) or rodent (1.0% [4]) models of stroke. In feline brain water uptake exceeding 5% was reported only by 24-48 hours of stroke [3]. Furthermore, data from primate stroke show that water uptake by white matter (WM) is less severe than that by gray matter (GM) [2]. Taking into account the water data above and the fact that the ischaemic core is effectively without blood supply, it is difficult to appreciate the water uptake values reported by Minnerup et al. [1]. One potential reason for high water uptake estimate by Minnerup et al. [1] could be the use of aqueous HU calibration instead of measurements of HUs against water content in the brain tissue [4].

Second, the procedure utilises mirror-reference approach where the ratio of HUs in the ischaemic core to the contralateral non-ischaemic mirror reference is used to compute percent water uptake. The mirror-reference approach assumes that any deviation from a ratio of 1 is due to pathology, i.e. acute ischaemia, and that the ratio increases with time.

This places strict requirements for accurate positioning of the mirror region [5] so that it contains equal volumes of brain tissue types (GM, WM and CSF space) to the lesion, because inherent water content in these tissue types greatly differs.

The paper by Minnerup et al. [1] underscores the potential value of quantitative imaging data in stroke patient management despite the water uptake calibration issue above. This as such does not affect the potential clinical utility of the CT approach. However, robustness of the presented CT approach for wide clinical use should be demonstrated in cohorts balanced in size with respect to the 4.5 hour time limit.

References

1. Minnerup J, Broocks G, Kalkoffen J, et al. Computed tomogrphy base quantification of lesion water uptake indentifies patients within 4.5 hours of stroke enset: A multicenter observational study. Ann Neurol. 2016;in press.
2. Watanabe O, West CR, Bremer A. Experimental regional cerebral ischemia in the middle cerebral artery territory in primates. Part 2: Effects on brain water and electrolytes in the early phase of MCA stroke. Stroke. 1977; 8:71-6.
3. O'Brien MD, Waltz AG, Jordan MM. Ischemic cerebral edema. Distribution of water in brains of cats after occlusion of the middle cerebral artery. Arch Neurol. 1974;30:456-60.
4. Dzialowski I, Weber J, Doerfler A, Forsting M, von Kummer R. Brain tissue water uptake after middle cerebral artery occlusion assessed with CT. J Neuroimaging. 2004;14:42-8.
5. Norton TJT, Pereyra M, Knight MJ, et al. Stroke onset time determination using MRI relaxation times without non-ischaemic reference in a rat stroke model. Biomed Spectr Imag. 2016:DOI 10.3233/BSI-160155.